Feasibility Study Appendix A2 - Ecological Risk Based Preliminary Remediation Goal (PRG) Derivation

Preliminary Remediation Goals (PRGs) in this Feasibility Study (FS) are based, in part, on risk based toxicity reference values (TRVs) for each medium of concern within the Portland Harbor Baseline Ecological Risk Assessment (BERA), and based in part on the results of site specific sediment toxicity tests presented in the BERA (Windward Environmental 2013). Ecological PRGs have been developed for three abiotic media: sediment, surface water, and transition zone water (TZW). These are the three media potentially subject to remediation and/or source controls intended to reduce risks to ecological receptors. The ecological PRGs are intended for use with medium-specific Remedial Action Objectives (RAOs) described in this section. Within the BERA, TRVs were contaminant concentrations in either environmental media or ingested as dietary doses above which unacceptable ecological risks potentially occur. BERA TRVs were selected or derived for use for each medium, target ecological receptor, and ecological exposure pathway combination assessed in the BERA. The PRGs for each contaminant are intended to represent contaminant concentrations in sediment, surface water or TZW that, if not exceeded, are protective of the assessment endpoints identified in the BERA. Many of the PRGs in this Appendix were selected from published compendia of sediment and water quality benchmarks, criteria or standards. In the case of ecological risks identified in the BERA through exceedances of tissue-based or dietary ingestion TRVs, PRGs in abiotic media were derived using one of several methods described in this Appendix. Ecological PRGs for sediment, surface water and TZW are presented in Tables A-1, A-2 and A-3, respectively.

Commented [SB1]: I've stripped out all of the risk based threshold (RBT) terminology, which is not used anywhere in the BERA

1.0 Sediment PRGs

Sediment PRGs were selected to meet the objectives of **RAO 5**, which are to reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated sediments. This RAO applies to all ecological receptors found to have an unacceptable risk via direct sediment exposure in the BERA. The goals are to: 1) reduce potentially unacceptable risks to ecological receptors from contaminant concentrations in sediments through sediment remedies at the Site; and 2) prevent unacceptable effects on the survival, growth, and reproduction of ecological receptors at the Site.

Commented [SB2]: Discussion of meeting ARARs text removed from this appendix based on discussion between Kristine and Burt on 7/16/14. The only ecological risk ARARs I can think of are Oregon's water quality standards for aquatic life, which should be very similar to EPA's ambient water quality criteria for aquatic life.

Sediment PRGs also were selected to meet the objectives associated with **RAO 6**, which are to reduce to acceptable levels risks to ecological receptors from indirect exposures through ingestion of prey exposed to contaminants of concern (COCs) in sediments and/or surface water. **RAO 6** applies to all ecological receptors found to have an unacceptable risk through ingestion of prey in the BERA. The goals are to: 1) reduce risks from contaminants through sediment and/or source control remedies that protect ecological receptors from exposures to contaminants bioaccumulated in fish and shellfish, benthic organisms, or other prey items; and 2) protect the beneficial uses of the Willamette River at the Site. This RAO is expected to contribute to reduction of prey ingestion related ecological risks via reduced contaminant concentrations in tissues of prey. It is recognized that reduction of and elimination of these risks can only be achieved when conducted in conjunction with other Portland Harbor source control efforts conducted under other regulations and programs within the Willamette River watershed.

Commented [SB3]: This reads as a Clean Water Act goal. Is this really what RAO 6 is meant to do?

The sediment PRGs presented in Table A1 that are based on either tissue residue or ingested dietary dose ecological risks from the BERA were generated using BSAFs, BSARs, or the FWM. Details of these approaches are described in ***Early Preliminary Remediation Goals*** (Windward Environmental et al. 2009), and are summarized in this Appendix. Food web model, BSAF and BSAR development for use in PRG derivation required assumptions about exposure areas of the species modeled. These assumptions impact the development of the bioaccumulation models and therefore the PRGs derived from these models as well as the scales at which the PRGs may be applied.

1.1 Sediment PRGs for RAO 5

At least 53 contaminants or groups of contaminants in sediment are identified as sediment COCs based on risks to benthic invertebrate species ingesting or in direct contact with sediment. These contaminants include total polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH), insecticides, metals, phthalates, and tributyltin (TBT).

Two types of PRGs were developed for RAO 5:

- PRGs expressed as contaminant concentrations in sediment, most of which are expressed in concentration units of either micrograms per kilogram (µg/kg) or milligrams per kilogram (mg/kg) dry weight (dw) sediment.
- Empirical, site specific sediment toxicity based PRGs, expressed in terms of a maximum allowable percent reduction in either survival or biomass (a survival-normalized growth endpoint) of one of two benthic invertebrate species: larvae of the insect *Chironomus dilutus*, and tests started with juveniles of the amphipod *Hyalella azteca*.

Sediment PRGs were selected or calculated from TRVs identified in the BERA for a number of the BERA sediment COCs. The complete set of contaminants in sediment PRGs for RAO 5 were derived from one of the following four TRV categories. Examples of contaminants whose PRGs were derived from one of the following methodologies are also presented.

- Logistic Regression Model (LRM) TRVs for protection of benthic macroinvertebrates
    - Hydrocarbons: Total HPAHs
    - Butyltins: Tributyltin
- Generic Sediment Quality Benchmarks (e.g. Probable Effects Concentrations or PECs; MacDonald et al. 2000)
    - Hydrocarbons: Total PAHs
    - Insecticides: aldrin, dieldrin, total DDx, gamma-HCH (Lindane), and total chlordanes
    - Metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc
- Tissue Residue-Based Effects Concentration
    - Total PCBs, bis(2-ethylhexyl)phthalate (BEHP)
- Total Petroleum Hydrocarbon (TPH) TRV Derivation (Shephard and Poulsen 2006)
    - $C_{10} – C_{12}$ aliphatic TPH fraction

Logistic Regression Models (LRM). Unlike other methods of deriving sediment quality benchmarks, LRMs do not derive threshold sediment contaminant concentrations above which

Commented [jp4]: It would be helpful to describe what methodology was used to develop the PRGs since the methods described by the LWG were not used in all cases.

Commented [TG5]: PEC for Hg = 1.1 as shown on TRV table, but not shown as selected for RBT for RAO 5. Not sure why 1.1 is not the Hg sediment RBT for RAO 5. BURT, CAN YOU COFIRM NON-SELECTION OF HG TRV AS RBT?

Commented [SB6]: The mercury PRG based on PEC concentrations is already in the table I'm reviewing, its shown as 1.06 mg/kg because Kristine is interested in showing PRGs where possible to 3 significant digits.. Apparently Tony reviewed an early, incorrect or incomplete version of Table A1

Commented [jp7]: The addition of background on the logic behind the selection of the PRGs would be helpful as well as their intended use. For example, for the bulk sediment SQGs it is not clear if these are to be used to predicted sediment toxicity for identifying areas for toxicity testing or if the use of these benchmarks were selected to achieve other goals related to ecological risk. I would still recommend using a model in its entirety to predict sediment toxicity. Perhaps given the problems with the FPM, the LRM could be used for this purpose. It is unclear the predictive capacity of the combination of these sediment TRVs derived from a range of sources. Additionally, since a wider range of chemicals are associated with toxicity in addition to other PRGs from other exposure/receptor combinations, it is unclear how this list of TRVs was selected.

adverse effects are expected to occur. Instead, the LRM estimates the probability of observing adverse effects to benthic species at a particular sediment contaminant concentration. As such, the LRM provides actual estimates of ecological risk (i.e. risk is the probability of an adverse effect) as opposed to an estimate of hazard (i.e. hazard is the potential of a stressor to cause adverse effects under specified conditions). Individual LRMs (Field et al. 1999; Field et al. 2002; EPA 2005) were developed for 68 chemicals of potential ecological concern (COPCs) from the Portland Harbor screening level ecological risk assessment (SLERA). For each chemical, model developers fit 72 unique models from which the best individual model was selected. For each chemical, the 72 individual models were developed using the following site-specific information:

• Two pooled species sediment toxicity test endpoints (i.e., *Hyalella azteca* and *Chironomus dilutus)*
• Three toxicity levels: Level 1 (low toxicity), Level 2 (moderate toxicity), or Level 3 (severe toxicity)
• Four sediment chemistry normalizations (i.e., dry weight, organic carbon (OC)-normalized, fines-adjusted dry weight concentrations, and fines-adjusted OC-normalized concentrations). The fines-adjusted, and fines-adjusted OC normalized TRVs developed in the Portland Harbor LRMs created difficulties in back transforming the normalized TRVs to a PRG expressed in units of µg/kg or mg/kg dry weight sediment. The full list of TRVs from the LRM is presented in Table 6-11 of the final Portland Harbor BERA.

Sediment PRGs derived from the LRM are at the lower end (i.e. smallest adverse effect) within the range of Level 2 (moderate toxicity) adverse effect concentrations.

Examples of LRM-based PRGs derived from sediment toxicity testing with *H. azteca* and *C. dilutus* include the following:

- Tributyltin (TBT) PRG (3.1 mg/kg dw sediment) is the Level 2 (Moderate toxicity) SQV from the LRM.
- High molecular weight PAH (HPAH) PRG (150 mg/kg dw sediment) is the Level 2 (Moderate toxicity) SQV from the LRM

Generic Sediment Quality based PRGs. Probable Effects Concentrations or PECs (MacDonald et al. 2000) are consensus-based contaminant sediment concentrations above which adverse effects on sediment-dwelling organisms are likely to occur. The PECs were derived as geometric means of five different sediment quality guidelines (SQGs) with similar narrative intent for each individual contaminant: probable effect levels (PELs), severe effect levels (SELs), toxic effect thresholds, effect range-median (ER-Ms) and probable effect levels for *Hyalella azteca* 28-day growth. Details of and the source of each of the five sets of SQGs are in MacDonald et al. (2000). All five of the source documents for the individual SQGs used to derive PECs are publically available in the literature.

Tissue-residue based Effects Concentration PRGs. TRVs For fish, sediment PRGs represent contaminant concentrations calculated to maintain whole body fish contaminant concentrations below those linked to ecologically significant adverse effects on fish themselves (i.e. not on species that feed on fish). Three procedures are available and were considered to identify sediment PRGs that will prevent unacceptable contaminant bioaccumulation in tissues: biota-sediment accumulation factors (BSAFs), biota-sediment accumulation regressions (BSARs) and the

Commented [SB8]: The smallmouth bass PCB PRG is unchanged from its derivation in the 2009 Early Preliminary Remediation Goals document cited earlier in this text. BEHP's PRG was derived using a BSAF approach and an assumed BSAF value of 4.0, the national average BSAF for hydrophobic organic chemicals, because of the lack of a relationship between BEHP concentrations in sediment and fish tissue at Portland Harbor.

mechanistic food web model (FWM). All three methods are described in detail in the *Bioaccumulation Modeling Report* (Windward Environmental 2009). Application of the bioaccumulation models to PRG derivation, as well as a number of the actual PRGs are presented in *Early Preliminary Remediation Goals* (Windward Environmental et al. 2009).

Commented [jp9]: All methods are described, but the methods used for the EPA selected PRGs are not referenced. Consider adding footnotes for this purpose. For example, "food web model as described by LWG" or "Developed using BSAF methodology, using a BSAF of 4" are necessary to guide the reader to derivation methods of each number. Ideally, fish estimation methods would be similar between human health and ecological risk assessments when the receptor endpoint is the same. For example, DDX modeled to smallmouth bass using a food web model for HH PRGs and a BSAF for the ERA is confusing.

The fundamental goal of all three approaches is to identify predictive relationships between contaminant concentrations in sediment and contaminant concentrations in either target ecological receptor tissues or the prey of target ecological receptors. The mathematically simplest approach to calculate sediment PRGs from tissue-based TRVs is the BSAF approach, calculated as follows:

$$PRG_{sediment} = \left[\frac{\left(\frac{TRV_{tissue}}{f_{Lipid}}\right)}{BSAF}\right] \times f_{OC}$$

Where: **$PRG_{sediment}$** = Preliminary remediation goal in sediment for a contaminant (µg/kg or mg/kg dry weight sediment)

TRV_{tissue} = Toxicity reference value for a contaminant in tissue (µg/kg or mg/kg wet weight tissue, with the same units as desired for $PRG_{sediment}$)

f_{Lipid} = Decimal fraction of the lipid content of the target ecological receptor (unitless)

BSAF = Biota-sediment accumulation factor (unitless)

f_{OC} = Decimal fraction of the organic carbon content of sediment (unitless)

BSAFs/BSARs were used to estimate PRGs when a linear relationship between co-located sediment and tissue concentrations could be established based on data collected for the baseline risk assessments. Linear relationships could be identified from untransformed sediment and tissue data, relationships where either the sediment or tissue contaminant concentrations were log-transformed (log-linear regressions), or where both sediment and tissue contaminant concentrations were log-transformed (log-log regressions). A BSAR assumes a relationship between the concentration of a bioaccumulative chemical in sediment and that measured in tissue. Frequently, the relationship between tissue and sediment concentrations is calculated as a simple ratio between tissue and sediment concentrations (BSAF) rather than as a BSAR. A BSAR can be considered as the slope of a regression between tissue and sediment concentrations. The BSAR approach can account for the common observation that the ratio between tissue and sediment concentrations can vary with changes in sediment concentrations, unlike a single BSAF value. BSAF ratios often become smaller at high sediment contaminant concentrations. The log transformations of sediment and/or tissue contaminant concentrations can account for the observed changes in BSAF with changes in sediment concentrations. Other reasons for preferring BSARs over BSAFs when possible included:

- BSAFs based on a simple ratio between sediment and tissue chemical concentrations do not allow for the possibility of background contributions to tissue from non-sediment sources.
- BSAFs are a special case of BSARs (i.e., linear equations with the intercept forced to equal zero), so regression modeling will produce a BSAF if justified by the data.

For species whose home range is smaller than the site, and therefore may have multiple sets of paired data for co-located tissue and sediment chemical concentration data (e.g. benthic invertebrates, sculpin, and smallmouth bass), sediment-tissue contaminant relationships were evaluated to determine if BSARs or BSAFs were justified for sub-sections of the site. Due to limited numbers of tissue samples within a sub-section of the site, this was generally not feasible.

Commented [jp10]: Yes, but consider that using that same limited tissue set to predict tissue "average" chemistry across the whole 9 miles has more problems. First, I don't think we are interested in the average, but rather segments of the river for exposure areas, and second, predicting an average given the heterogeneity in sources and concentration magnitude has even a GREATER uncertainty. I would argue that the use of composites over smaller areas to develop sediment to tissue relationships is more applicable and has less uncertainty.

For contaminants where site-specific BSAFs, BSARs or the FWM could not identify relationships between sediment and tissue concentrations, but for which risk managers requested sediment PRGs, EPA recommended the use of a nationwide theoretical bioaccumulation potential BSAF of 4.0 for hydrophobic organic chemicals (U.S. Army Corps of Engineers 2003, Appendix G). EPA recommended use of the default BSAF of 4.0 *in lieu* of a second proposed default BSAF of 1.7 (U.S. Army Corps of Engineers 2003, Appendix G), as the larger BSAF resulted in more protective sediment PRGs. The default BSAF approach was used, for one example, in the derivation of the bis(2-ethylhexyl)phthalate sediment PRG for protection of piscivorous fish.

Total Petroleum Hydrocarbon PRGs. This PRG derivation method can be considered a special case of the tissue residue based effect concentration TRV approach described earlier. Petroleum is a complex mixture of literally hundreds of individual chemicals. The BERA TRVs for TPH were based on the observation that for aquatic species, most of the individual chemicals in petroleum mixtures elicit toxicity by a mechanism of action known as narcosis (Di Toro et al. 2000, Snyder 1987). When tissue concentrations of narcotics are expressed in molar concentration units instead of the more commonly used mg/kg or µg/kg units, it has been observed that adverse effect concentrations of narcotic chemicals are nearly constant. Mortality is observed between 2 – 8 millimoles/kilogram (mmol/kg) in tissue, with chronic no effect tissue residues on survival, reproduction and growth observed to be about 10x lower than the lethal body burdens (McCarty and Mackay 1993). Based on a literature review of chronic toxicity of narcotic organic chemicals present in petroleum mixtures, Shephard and Poulsen (2006) set a chronic no effect tissue residue for TPH compounds at 0.24 mmol/kg.

Most importantly for the derivation of TRVs and PRGs for a complex mixture such as petroleum, the composition of a mixture of narcotic chemicals causing toxicity is not important. Toxicity from a mixture of narcotic chemicals such as petroleum occurs when the sum of individual chemical molar concentrations of the mixture in tissue exceeds the critical body residue of 0.24 mmol/kg.

A bioaccumulation model was then run backwards, starting with a surrogate chemical to represent all chemicals within a pre-defined TPH fraction, which for FS purposes was the C_{10} – C_{12} aliphatic fraction. n-Undecane (a C_{12} straight chain alkane) was used as the surrogate compound for the C_{10} – C_{12} aliphatic fraction. Results of the bioaccumulation model yielded the water concentration of the surrogate compound that resulted in bioaccumulation in tissue of the maximum allowable molar concentration of TPH compounds of 0.24 mmol/kg. These calculated water concentrations were the TRVs used to evaluate ecological risks to fully aquatic species (e.g. fish, aquatic invertebrates, aquatic plants) in the BERA. If needed, the TPH in water TRVs calculated from this intermediate step in the derivation of TPH in sediment PRGs would become the surface water and/or TZW PRGs for TPH fractions in the FS.

Sediment PRGs were then calculated by using the calculated water quality TRV into a calculation of sediment contaminant concentrations using the EPA (2003) equilibrium partitioning approach for sediment quality guidelines. The calculated sediment concentration of 11 mg/kg C_{10} – C_{12} aliphatic fraction was set as the sediment PRG for this TPH fraction.

Empirical Site Specific Sediment Toxicity Test Based PRGs. Sediment toxicity test based TRVs are expressed as the minimum allowable percent survival or the minimum percent biomass relative to survival or biomass in the laboratory negative control sediment response for each of four sediment toxicity test endpoints.

- *Chironomus dilutus* survival must be greater than 84%
- *Chironomus dilutus* biomass must be greater than 82% of control sample biomass
- *Hyalella azteca* survival must be greater than 79%
- *Hyalella azteca* biomass must be greater than 59% of control sample biomass

The above breakpoints for minimum allowable survival or biomass were derived from a site- and toxicity test-specific approach for identifying reductions in survival or biomass greater than what would be expected at relatively contaminant unimpacted portions of Portland Harbor. This approach, termed the reference envelope approach, is described in detail in Section 6 of the final BERA and its associated attachments. For a station to not meet a toxicity based PRG, these PRGs for survival or biomass must also be statistically significantly reduced from the laboratory negative control sediment survival or biomass (i.e. ***Both*** the absolute magnitude of the survival or biomass reduction PRG criterion ***and*** the reduction must be statistically significantly different than control response criterion ***must*** be met before a failure to meet a toxicity test based PRG is identified).

Commented [jp11]: Section 2 descirbes that both biomass and survival endpoints have to hit in order for it to be considered a PRG exceedance. If that is the case for interpretation of PRGs, that justification should be described here.

Level 1 (low toxicity) adverse effect levels from site specific sediment toxicity tests in the BERA were not used to derive sediment PRGs in this FS for one of two reasons. Either the percentage reduction in survival or biomass from the toxicity tests overlapped the allowable control mortality or biomass reductions in the ASTM and EPA sediment toxicity testing methodology test acceptability criteria, or the Level 1 reductions in survival or biomass were not statistically significantly different from control sample survival and biomass.

1.2 Sediment PRGs for RAO 6

Between all avian and mammalian target ecological receptors in the BERA, a total of 10 organic contaminant dietary TRVs were exceeded. Risks from dietary ingestion of contaminants to one or more bird or mammal target ecological receptors were identified for total PCBs, bis(2-ethylhexyl)phthalate, DDE, aldrin, benzo(a)pyrene, dibutyl phthalate, total DDx, dioxin/furan TEQ, PCB TEQ and total TEQ. This is the list of contaminants for which sediment PRGs for evaluation of **RAO 6** (dietary ingestion route of exposure) could be developed. Sediment PRGs protective of the BERA avian and mammalian assessment endpoints from dietary ingestion of organic contaminants were calculated as follows:

$$PRG_{sediment} = \left[\frac{\left(\frac{TRV_{dietary}}{FIR}\right)}{(BSAF \times f_{Lipid})}\right] \times f_{OC} \times CF$$

Where: **$PRG_{sediment}$** = Preliminary remediation goal in sediment for a contaminant (µg/kg or mg/kg dry weight sediment)
$TRV_{dietary}$ = Toxicity reference value for a contaminant in the diet or prey of the target ecological receptor (mg/kg or mg/kg BW/day, where BW is the body weight of the target receptor)
FIR = Food ingestion rate of the target ecological receptor (kg/day or kg/kg BW/day)

f_{Lipid} = Decimal fraction of the lipid content of the food or prey of the target ecological receptor (unitless)
BSAF = Biota-sediment accumulation factor from sediment to prey (unitless)
f_{OC} = Decimal fraction of the organic carbon content of sediment (unitless)
CF = Conversion factor (depending on the contaminant- and species-specific units of $TRV_{dietary}$ and/or FIR, may be needed to ensure $PRG_{sediment}$ is expressed in the desired concentration units)

For the piscivorous bird assessment endpoint of the BERA, it was also possible to calculate sediment PRGs from contaminant in bird egg tissue TRVs for PCBs, dioxins/furans, total DDx and DDE. Parental contaminant levels accumulated from the diet of birds are in turn deposited in bird eggs via maternal transfer. Sediment PRGs from the bird egg line of evidence in the BERA were calculated as follows:

$$PRG_{sediment} = \left[\frac{\left(\frac{TRV_{bird\ egg\ tissue}}{BMF_{prey\ to\ egg}}\right)}{(BSAF \times f_{Lipid})}\right] \times f_{OC} \times CF$$

Where: **$PRG_{sediment}$** = Preliminary remediation goal in sediment for a contaminant (µg/kg or mg/kg dry weight sediment)
$TRV_{bird\ egg\ tissue}$ = Toxicity reference value for a contaminant in the eggs of the target avian receptor (mg/kg)
BMF = Prey to egg biomagnification factor (unitless)
f_{Lipid} = Decimal fraction of the lipid content of the food or prey of the target ecological receptor (unitless)
BSAF = Biota-sediment accumulation factor from sediment to prey (unitless)
f_{OC} = Decimal fraction of the organic carbon content of sediment (unitless)
CF = Conversion factor, may be needed to ensure $PRG_{sediment}$ is expressed in the desired concentration units

2.0 Surface Water PRGs

Surface water PRGs were selected to meet the objectives associated with **RAO 6**, which is to reduce to acceptable levels risks to ecological receptors from indirect exposures through ingestion of prey exposed to contaminants of concern (COCs) in surface water.

Surface water PRGs also were selected to meet the objectives associated with **RAO 7**, which are to reduce risks from COCs in surface water within Portland Harbor to acceptable exposure levels protective of ecological receptors based on the ingestion of and direct contact with surface water. This includes species with gills or other respiratory exchange surfaces that are in direct contact with surface water. The goals are to: 1) reduce potentially unacceptable risk from contaminant concentrations in surface water to the extent practicable, through both sediment remediation and source control; and 2) protect the beneficial uses of the Willamette River. The current EPA aquatic life criteria table is available on the Internet at:

Commented [SB12]: Again is this really an RAO objective or just someone who knows something about the Clean Water Act?

http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable

The most recent published version (in PDF format) of the EPA aquatic life criteria table is EPA (2009).

2.1 Surface Water PRGs for RAO 6

Based on the available surface water TRVs in the BERA, ten COCs were quantitatively identified for surface water (i.e. one or more samples with a hazard quotient ≥ 1.0). All 10 surface water COCs were identified for fully aquatic species. Surface water risks to aquatic-dependent birds and mammals were not independently evaluated in the BERA. This was because based on the water ingestion rates relative to food ingestion rates, wildlife risks from ingested surface water were anticipated to be negligible relative to contaminant risks from dietary ingestion (i.e. risks to aquatic-dependent wildlife via surface water ingestion were a complete but insignificant exposure pathway as defined in the BERA conceptual site model). However, based on measured exceedances of published EPA aquatic life criteria and Oregon water quality standards, two surface water contaminants were identified as requiring PRGs for use in evaluating aquatic-dependent wildlife risks under RAO 6. The two contaminants with surface water PRGs for evaluation of wildlife under RAO 6 were:

- Total PCB (0.014 µg/L)
- Total DDx (0.001 µg/L)

The surface water PRGs for total PCBs and total DDx are the published EPA chronic aquatic life criteria for these two contaminants, which have also been promulgated as Oregon's aquatic life standards.

Normally, EPA aquatic life criteria are derived to be protective of fully aquatic species. However, the procedure by which EPA aquatic life criteria are derived (Stephan et al. 1985) also permits aquatic life criteria to be derived which are protective of aquatic-dependent species such as osprey and mink. The goal of aquatic life criteria derived in this manner is to protect wildlife that consume aquatic organisms from demonstrated unacceptable effects.

In the case of PCBs, the chronic aquatic life criterion is based on the protection of mink from unacceptable reproductive and survival risks due to ingestion of PCB-contaminated food. For DDx, the chronic aquatic life criterion is based on protecting the reproductive success of brown pelican, which is adversely affected by consuming DDT contaminated fish.

2.2 Surface Water PRGs for RAO 7

The surface water TRVs in the BERA that resulted in identification of 10 surface water COCs were selected as surface water PRGs for RAO 7. Three sources of BERA surface water TRVs were used as surface water PRGs for RAO 7: EPA aquatic life criteria (EPA 2009 and updates from the website shown in Section 2.0 of this Appendix), Tier II aquatic life values (Suter and Tsao 1996), and BERA developed surface water TRVs for PCBs and DDx. Examples of each are presented below, the full list of surface water PRGs is in Table A-2. In all cases these PRGs are based on chronic criteria or chronic values with a narrative intent of protecting 95% of aquatic genera (Stephan et al. 1985). Aquatic life is defined for this purpose as aquatic plants (including macrophytes, phytoplankton and periphyton), zooplankton, benthic invertebrates, fish, and larval amphibians).

- Chronic National Recommended Water Quality Criteria (EPA 2009 and updates), adjusted to a hardness of 25 mg/L as $CaCO_3$ in the case of metals (water hardness of the Willamette River at Portland is between 25-30 mg/L as $CaCO_3$)
    - Zinc

- Tier II Secondary Chronic Values (Suter and Tsao 1996)
    - Ethylbenzene
    - BEHP
    - Benzo(a)anthracene
    - Benzo(a)pyrene
    - Naphthalene
    - Trichloroethene (TCE)

- BERA Derived TRVs for Fully Aquatic Species
    - Total DDx (also used for 4,4'-DDT)
    - Total PCB

3.0 Transition Zone Water (TZW) PRGs

TZW PRGs were selected to meet the objectives associated with **RAO 8**, which are to reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated TZW. This includes risks to species that consume prey that have been exposed to and bioaccumulated TZW contaminants. The goal is to reduce potentially unacceptable risks to ecological receptors from contaminant concentrations in TZW by protection of the appropriate BERA assessment points of survival, reproduction and growth. The receptor groups for which TZW risks were evaluated were aquatic plants, benthic invertebrates, invertivorous fish, detritivorous fish, and amphibians. RAO 8 primarily applies to receptors exposed to TZW plumes downgradient of upland sources.

3.1 Transition Zone Water (TZW) PRGs for RAO 8

The BERA quantitatively identified 57 COCs for TZW. The sources of these TRVs serving as TZW PRGs for RAO 8 are largely the same as those used to derive surface water PRGs: EPA (2009 and updates) aquatic life criteria and Tier II criteria (Suter and Tsao 1996). For m-xylene and p-xylene, a correction (EPA 2006) to Suter and Tsao (1996) was the source of these two TZW PRGs. A water TRV and subsequent PRG for perchlorate was originally identified in the BERA Problem Formulation from Dean et al. (2004), who used the same methodology EPA uses to derive aquatic life criteria to derive a chronic perchlorate TRV. The derivation for TPH fraction PRGs in water (Shephard and Poulsen 2006, CONCAWE 1996) has already been summarized in Section 1.1 of this Appendix. Examples of contaminants in TZW whose PRGs were derived using each of the above methods are shown in the remainder of this section. The full list of transition zone water PRGs is presented in Table A-3.

- Chronic National Recommended Water Quality Criteria (EPA 2009 and updates), adjusted to a hardness of 25 mg/L $CaCO_3$ in the case of metals with hardness-dependent criteria
    - Lead
    - Zinc

    - Cyanide

- Tier II Secondary Chronic Value (Suter and Tsao 1996)
    - Naphthalene
    - Benzo(a)pyrene
    - Benzene
    - 1,2-Dichlorobenzene
    - Ethylbenzene
    - Vanadium
    - Toluene
    - o-Xylene
    - Total Xylene

- Memorandum from D. Mount to ERAF tri-chairs. September 2006: Error in prior calculation of GLI Tier II SCV for m-xylene. National Health and Environmental Effects Research Laboratory, US Environmental Protection Agency, Duluth, MN (EPA 2006)
    - m- and p-Xylene

- PRG (Dean et al. 2004) developed using methods for derivation of EPA aquatic life criteria
    - Perchlorate

- TPH fraction TZW PRGs derived as per Shephard and Poulsen (2006) and CONCAWE (Conservation of Clean Air and Water in Europe). 1996. An overview of the TZW PRG derivation is given in Section 1.1 of this Appendix, as derivation of water column TRVs that can be used as PRGs in water is an intermediate step in the development of sediment PRGs for TPH fractions.
    - TPH (C_{10} to C_{12} aliphatic fraction)

4.0 References

Conservation of Clean Air and Water in Europe (CONCAWE). 1996. Environmental risk assessment of petroleum substances: the hydrocarbon block method. Report no. 96/52.

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EPA. 2009. National Recommended Water Quality Criteria. U.S. Environmental Protection Agency, Office of Water and Office of Science and Technology, Washington, DC.

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